Cerebral Arterial Spasm*

Part 1: Evaluation of Experimental Variables Affecting the Diameter of the Exposed Basilar Artery

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The technique of direct observation of cerebral arteries in vivo has been used for over 100 years to study the physiology of the circulation of the brain. For the study of certain phenomena, such as cerebral arterial spasm, this technique surpasses all others, for only by direct observation can one determine continuously the status of a focal segment of a blood vessel without alteration of its integrity at the instant of observation. Exposed arteries are, however, subjected to many variations in their external environment and may also reflect the physiological changes in the experimental animal. A knowledge of the response of arteries to these variables is of value not only in planning new experiments involving direct observation of intracranial vessels, but also in interpreting old data from previous experiments in which exposed arteries were involved. This report summarizes the effects that some of these variables have on the exposed basilar artery of the cat under controlled conditions.

Preparation

Adult cats were anesthetized with intraperitoneal pentobarbital, 30 mg/kg body weight. The animals were placed on an electric heating pad, and body temperature, as measured with a rectal thermistor, was maintained at 37° to 39°C. A tracheostomy was performed, and a Harvard respirator was used for controlled respiration. A polyethylene catheter was placed in a femoral artery and attached to a Sanborn transducer for continuous monitoring of arterial pressure. A polyethylene catheter was placed in the femoral vein for drug administration. The mouth was held open with a self-retaining retractor. The tongue was withdrawn and clipped to the lower lip with Allis clamps.

The palate was incised in the midline using an electroscalpel. The posterior pharyngeal mucosa and musculature were also split with the electroscalpel and dissected from the bone. Traction sutures were placed through this tissue as well as through the tissues of the soft palate and these structures were retracted laterally.

A 5 mm burr hole was made in the clivus with an electric drill, and the clivus was removed with rongeurs from the rim of the foramen magnum to the level of the midpons. After the bone edges were thoroughly waxed, small rolls of cotton were placed beneath them for hemostasis. A needle thermistor was inserted through the upper lip with its tip over the hard palate. The tip of a polyethylene catheter was tied to the thermistor. The opposite end of the catheter was placed in a flask of mammalian Ringer's solution in a constant temperature bath. The flask was sufficiently higher than the mouth so that the Ringer's solution flowed through the catheter by gravity at a rate of approximately 5 ml/min. A stab wound was made in the lateral aspect of the tongue, and a polyethylene catheter was passed through this opening to the lower edge of the foramen magnum for continuous aspiration of irrigation solution. Continuous irrigation was then started, the exposed area being irrigated with Ringer's solution at 37° to 39°C via the polyethylene catheter.

For the remainder of the procedure the operative microscope was used. The dura was opened in the midline. Traction sutures,
usually four in number, were placed to retract the dura laterally and hold it snugly against the bone edges. The arachnoid was removed from a portion of the exposed vessel by gentle dissection with a special hook fashioned from a dental probe, with a cutting edge on its upper surface. Meticulous attention was given to hemostasis at each stage of the operative procedure so that at the time the arachnoid was opened there was absolutely no bleeding.

Photographs of the exposed vessel were made using Kodak EHB-135 color film in a 35 mm camera attached to the operative microscope. Photographs were made before and at specified intervals after manipulation of the vessel or beginning irrigation with various solutions. The photographs were projected, and the diameter of the basilar artery was measured with a millimeter ruler. The results were expressed as per cent change (+ for dilatation and − for constriction) in vessel diameter relative to control diameter immediately prior to manipulation or application of solution. When segmental constriction occurred in the photographed area of the vessel, the area of maximum constriction was selected for measurement. The techniques for the various manipulations of the vessel, and for preparation of solutions to be assayed for vasoactivity, will be described subsequently.

When multiple studies were done on an animal, at least 10 minutes were allowed to elapse between studies. More time was allowed when necessary to allow arterial pressure and vessel diameter to return to baseline values.

**Experimental Variables**

*Variability of Measurement.* To determine the standard error of measurement of photographs, serial photographs were taken at 1-min intervals for 10 min in two cats in which systemic and local factors were not changed. For the 22 measurements (11 measurements per cat) the standard deviation from the mean vessel diameter was ±7.25%. To further evaluate the reproducibility of the measurement techniques, duplicate photographs of normal vessels from 30 animals taken within 1/2 to 1-min intervals were analyzed, comparing the per cent change of the second reading from the first. In this group the second reading averaged 0.4 ± 4.3% larger than the first. Thus, in comparing a single measurement with its control, changes within the limits of −3.9% to +4.7% would fall within one standard deviation, and changes within −8.2% to +9.0% would fall within two standard deviations of the error of measurement.

*Arachnoid Dissection.* With experience, the arachnoid could be removed with less obvious trauma to the vessel, although in almost all animals the arachnoid was attached to the vessel by avascular fibers, and it was therefore impossible to completely avoid mechanical stimulation of the vessel. In some animals a branch of the basilar artery was unintentionally torn or cut during arachnoid removal.

Photographs of normal vessels were taken before and 1 min after arachnoid removal in 12 cats. In this group, the vessel constricted 16.4% following arachnoid removal. It is of interest to compare the first six animals in this group, in which the average constriction was 30.2%, with the last six animals, in which the average constriction was 2.6%. The only factor known to have changed during the evolution of the study was the experience of the operator.

In three animals, photographs were made 1 min following arachnoid removal during which a branch of the basilar artery was inadvertently cut. Constriction in these animals averaged 46%. Spasm was quite persistent when arachnoid dissection was associated with bleeding, as shown in Fig. 1. When arachnoid removal was not associated with bleeding, however, any spasm which

![Fig. 1. Sequential changes of constriction produced by bleeding during arachnoid removal. Each line represents the data from one animal.](image)